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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A report on

ADHESIVES FOR EXTRUDED PCC CURB

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State of California
Department of Public Works
Division of Highways
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MATERIALS AND RESEARCH DEPARTMENT

January 15, 1957

Mr. E. Withycombe
Assistant State Highway Engineer
California Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A report on

ADHESIVES FOR EXTRUDED PCC CURB

Study made by	Technical Section
Under general direction of	Bailey Tremper
Tests performed by.	Frank C. Norris
Report Written by	Frank C. Norris and Bailey Tremper

Very truly yours,

F. N. Hveem
Materials & Research Engineer

cc: M.Harris
FWPanhorst
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District Engineers

ADHESIVES FOR EXTRUDED PCC CURB

The tests reported below were made to compare a number of adhesives that might be used to cement extruded PCC curbs to a plant mix base. This type of construction has been used experimentally in Districts IV and VII and has been proposed as a contract item. In the experimental installations referred to above, it is understood that an epoxy-thiokol adhesive was used. Properly formulated adhesives of this type are amply strong in bond. With such an adhesive, however, the limiting factor against displacement of the curb appears to be the strength of the plant mix base, which when fresh, has very little cohesion or tensile strength. It is conceivable that other, less costly, adhesives of lower inherent strength would provide as stable a curb as the epoxy-thiokol adhesives.

The following test procedure was used to evaluate the stability of curbs cemented to a plant mix surface with eight different adhesives.

The plant mix surface selected was a strip just west of the Butler Building occupied by our Library at 59th Street and Folsom Boulevard. It had been in place about three weeks. The surface was washed with water the day before test and just prior to test it was swept thoroughly. The simulated curb specimens were 6-inch cubes of a very dry sand-pea gravel concrete. The adhesive was applied to an area 6 inches square and a wood form was placed over the area. The concrete was placed in the form and vibrated. The top surface of the blocks was sprayed with pigmented curing compound. Overspray adjacent to the specimens appeared to soften the surface of the plant mix but this effect was only temporary. At the time of test the surface appeared to have hardened to its original condition.

The following adhesives were used in this program:

1. Blank. Concrete cast directly on the surface. 6 specimens.

2. Epoxy-Thiokol (Epon 820). 6 specimens.

a	Shell Epon Resin 820	633 grams
	Marter White Silica	220 grams
b	Thiokol, LP-3	253 grams
	DMP-30	63.3 grams

Adhesives for Extruded PCC Curb

2. Epoxy-Thiokol (Epon 820) (Continued)

a and b were mixed together just prior to use.

The adhesive was applied at the rate of 25 square feet per gallon which produced a film thickness of 1/16-inch. The approximate cost of the materials in the adhesive is $0.35 per square foot.

3. Indaco 200, 6 specimens

This material, an asphalt-latex emulsion was used after the addition of 1 percent of sodium silicofluoride. It was applied at the rate of 100 square feet per gallon, giving a film thickness of 0.016 inch.

4. Daraweld (Dewey and Almy Chemical Co.) 6 specimens.

In accordance with the manufacturer's directions, 1 part Daraweld, 1 part water and 4 parts portland cement, by weight were mixed together to form the adhesive. It was found however, that the proportion of portland cement had to be reduced somewhat to obtain a viscosity low enough for application.

It was applied at the rate of 25 square feet per gallon which produced a film thickness of 1/16-inch. The cost of materials in the mixed adhesive is $0.07 per square foot.

5. Neoprene Latex (DuPont No. SH 1996-1) 6 specimens.

The material ordered by this name was supplied by Industrial Products, Inc., 131 Whitethorne Way, Burlingame, California, under the label "AMC Heavy Duty Concrete Seal".

1 part by weight of this compound was mixed with 3 parts of lumnite cement to form the adhesive

It was applied at the rate of 25 square feet per gallon which produced a film thickness of 1/16-inch. The cost of materials in the mixed adhesive is $0.08 per square foot.

Adhesives for Extruded PCC Curb

6. Emulsified Asphalt, mixing type, 50-60 penetration 6 specimens.

It was applied at the rate of 100 square feet per gallon producing a film thickness of 0.016 inch. The cost is $0.002 per square foot.

7. Epoxy-Thiokol (Epon 815) 3 specimens

a	(Shell Epon Resin 815	148 grams
	(Marter White Silica	52 grams
b	(Thiokol LP-3	59 grams
	(DMP-30	148 grams

a and b were mixed together just before use.

The adhesive was applied at the rate of 25 square feet per gallon, producing a film thickness of 1/16 inch. The cost of materials in the adhesive is $0.35 per square foot.

8. Roseville Adhesive (Plastic). 3 specimens

Furnished by Roseville Dry Mix Products Co., Box 830, Roseville, California. The materials supplied were an adhesive in liquid form (evidently polyvinyl acetate) and a blend of "waterproof" cement and fine sand designated as "Plastic Cement-Exterior Stucco." In accordance with the manufacturer's directions, the materials were mixed in the nominal proportions by weight of 1 part adhesive, 2 parts water, and 60 parts of cement-sand blend.

After mixing, it was applied as follows in accordance with printed directions:

1. The pavement surface was dampened with water,
2. The straight adhesive was brushed in the pavement,
3. After the adhesive has become tacky, the complete mixture was spread to a thickness of about 1/16 inch,
4. The concrete specimen was cast.

Adhesives for Extruded PCC Curb

9. Roseville Adhesive (Regular) 3 specimens.

This was furnished by Roseville Dry Mix Products Co. It was proportioned and applied in the same manner as above except that "Dry Mix Topping Grout" containing regular portland cement was used in place of "Plastic Cement-Exterior Stucco."

Groups 1 to 6 inclusive, were cast on October 22, 1956. The weather was warm and the surface temperature of the pavement was between 86 and 93°F. Rain fell on the 23rd. Succeeding weather was dry but cool.

Groups 7 to 9 inclusive, were cast on October 24, 1956. The weather was clear but cool. The surface temperature of the pavement reached a maximum of 80°F in the sun.

The stability of the blocks in place was tested on November 7, 1956.

The tests were conducted with a gage-equipped hydraulic jack graduated in 100-pound increments. The jack was supported in a horizontal position at ground level against the concrete foundation of the adjacent building. Pressure against the block was obtained by means of 4" x 6" timber with a stepped end so that there was approximately an area of 1" x 4" in contact with the block. The tests were conducted in two ways:

1. Shear in which the end of the timber bore against the lower 1 inch of the test specimen,

2. Cantilever in which the end of the timber bore against the top edge of the specimen. Because of slope of the pavement it is probable that contact was obtained only along the top edge of the specimen, resulting in a lever arm of 6 inches.

The total load required to dislodge the specimen was divided by the area of failure, nominally 36 square inches, in order to obtain a value of shear strength in psi. When the block was cast on the epoxy adhesives, the latter yielded while still plastic and resulted in a hardened surface having an area somewhat greater than that of the block. Failure of these

specimens was always through the plant mix base. The area of failure was somewhat greater than that of the block. In computing the unit shear stress the total load was divided by the gross area of failure. Extension of the area of failure beyond that of the test block was not common with the other adhesives.

Unit stress in the cantilever tests was computed by the flexure formula (taking account of the extended area with Epon adhesive) for a beam loaded at one end and fixed at the other end.

$$R = \frac{W\,l}{Z} \qquad Z = \frac{b\,d^2}{3}$$

in which
- R = modulus of rupture in lbs. per sq. in.
- l = lever arm in inches
- b = width (perpendicular to direction of load), inches
- d = depth (parallel to direction of load), inches
- W = load at failure, pounds

The results of the tests are given in Tables I and II.

The average unit stress of all specimens in which failure occurred in the adhesive bond was 40 psi in shear and 41 psi in cantilever. Corresponding values when failure was through the plant mix base, were 60 psi in shear and 59 psi in cantilever. Both types of test gave nearly the same average unit stress. Presumably the value obtained is an expression of tensile strength or cohesion.

A value of R = 60 in the cantilever test is equivalent to a cohesiometer value of 900. Tests in the pavement section show that a cohesiometer value of 900 at 80°F is equivalent to about 150 at 140°F. Fresh plant mix samples usually give cohesiometer values of about 150. Thus the data indicate that the particular plant mix surface used in these tests is normal with respect to that to be expected in average construction.

It appears, therefore, that with many of the adhesives tested, the limiting stability is that of the plant mix itself. The adhesive need be no stronger than that required to develop such a strength. Judged by this criterion the following adhesives developed substantially the required strength of 60 psi:

Adhesives for Extruded PCC Curb

Epoxy-thiokol (Epon 820)
Daraweld-Portland Cement
Neoprene Latex-Lumnite
Emulsified Asphalt

Epoxy-thiokol (Epon 815) developed only 49 psi in shear by the single test made. The results are therefore, inconclusive at present.

Indaco 200, Roseville Plastic and Roseville Regular failed by a margin sufficient to warrant disqualification.

The conclusions reached above should be tempered by the following considerations. Daraweld was found to soften materially in the presence of water. The temperature at which the emulsified asphalt was tested was probably in the range of 70 to 80°F. At probable summer temperatures it might develop considerably less strength. The grade used, 50-60 penetration, may not be readily available. Softer grades probably would not give as good results.

It should also be noted that changes in temperature are more likely to affect the strength of the plant mix base than the adhesive (with the probable exception of emulsified asphalt). Thus at summer temperatures all of the adhesives tested might be shown to be equally effective. Under low winter temperatures the four adhesives found in these tests to be approximately equal might give a significant spread.

Of the two tests, the cantilever is thought to be the more significant because contact with the wheels of a vehicle probably would be at the upper edge of the curb.

Photos showing the blocks during and after test are reproduced as Figures 1 and 2.

CONCLUSIONS

Of the adhesives tested, Epoxy Thiokol and Neoprene Latex appear to offer the best promise of satisfactory performance when used to cement extruded concrete curbs to a fresh plant mix surface. Of the two, the Neoprene Latex adhesive is substantially lower in cost.

TABLE I

SHEAR TESTS

	Adhesive	Gross Load Pounds	Area of Failure Sq. In.	Shear Strength PSI	Failure Occurred in:
1.	None	2400	36	67	Bond
	"	1400	36	39	"
	"	400	36	11	"
	"	2800	48	58	Base
	"	0	36	0	Bond
				35	
2.	Epon 820	2600	60	43	Base
	" "	3400	42	81	"
	" "	3600	68	53	"
	" "	3400	58	59	"
				59	
3.	Indaco 200	1900	36	53	Bond
	" "	1300	36	36	"
	" "	1800	36	36	"
				42	
4.	Daraweld	2500	36	70	Base
	"	2800	36	78	"
				74	
5.	Neoprene	2500	36	70	Base
		2000	36	56	"
				63	
6.	Emulsified Asphalt	2000	36	55	Base
		2300	36	64	Bond
				60	
7.	Epon 815	2050	42	49	Base
8.	Roseville Plastic	2300	56	41	Base
9.	Roseville Regular	1250	36	35	Bond

TABLE II

CANTILEVER TESTS

Adhesive	Gross Load Pounds	b Inches	d Inches	Z In.^{3}	R Lbs/sq.in.	Failure Occurred in:
1. None	0	6	6	72	0	Bond
2. Epon 820	800	7	6	84	57	Base
" "	1200	7	7¼	122	59	"
					58	
3. Indaco 200	700	6	6	72	59	Bond
" "	300	6	6	72	25	"
" "	200	6	6	72	17*	"
					42	
4. Daraweld	800	6	6	72	67	Bond
"	800	6	6	72	67	Base
"	600	6	6	72	50	"
"	600	6	6	72	50	"
					61	
5. Neoprene	800	6	6	72	67	Base
"	800	6	6	72	67	"
"	400	6	6	72	33	"
"	750	6	6	72	63	"
					57	
6. Emulsified Asphalt	900	6	6	72	75	1/2 base, 1/2 bond
	900	6	6	72	75	Base
"	400	6	6	72	33	Base
"	550	6	6	72	46	60% base, 40% bond
					57	
7. Epon 815	750	6	6	72	63	1/2 base, 1/2 bond
" "	900	6	6	72	75	70% base, 30% bond
					69	
8. Roseville Plastic	550	6	6	72	45	Bond
	450	6	6	72	37	"
					41	
9. Roseville Regular	650	6	6	72	54	Bond
	500	6	6	72	42	"
					48	

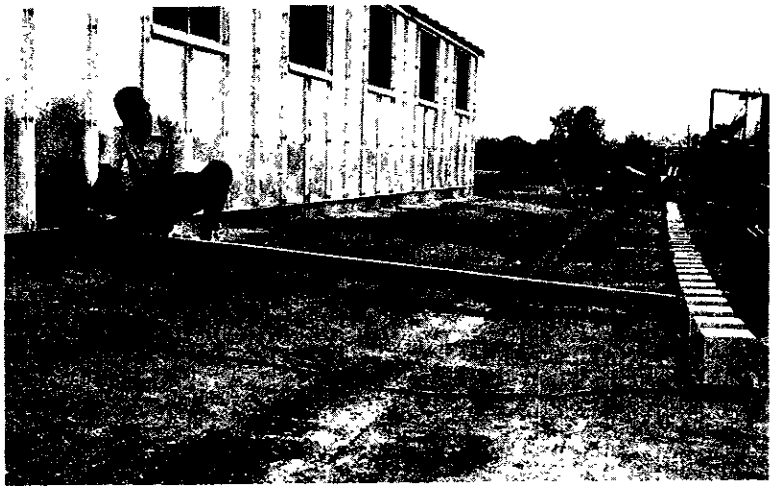
*Not included in average because failure occurred partly by rupture through a dirt layer barely below the pavement surface.

TABLE III

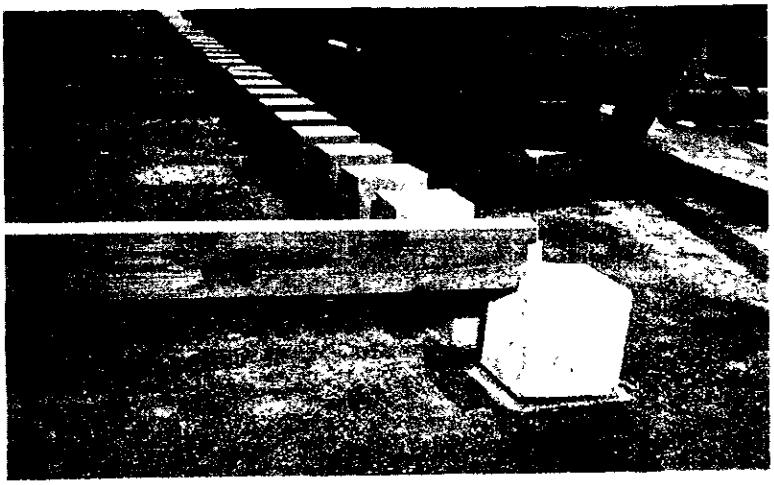
SUMMARY OF DATA

Adhesive	Type	Cost (Materials Only) per gal.	Cost (Materials Only) per sq. ft.	Average Test Strength Shear psi	Average Test Strength Cantilever psi
None				35	0
Epon 820	Epoxy-Thiokol	$8.75	$0.35	59	58
Indaco 200	Asphalt-Latex			42	42
Daraweld	Polyvinyl acetate-Portland Cement	1.75	0.07	74	61
Neoprene	Neoprene latex-Lumnite cement	2.00	0.08	63	57
Emulsified Asphalt	Mixing type 50-60 Pen.	0.20	0.002	60	57
Epon 815	Epoxy-Thiokol	8.75	0.35	49	69
Roseville Plastic	Polyvinyl acetate-plastic cement mortar			41	41
Roseville Regular	Polyvinyl acetate-portland cement mortar			32	48

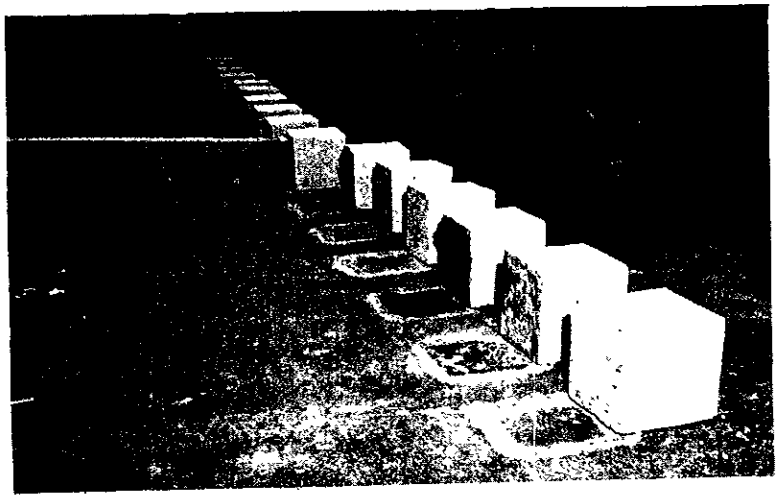
Figure 1



Method of dislodging the blocks

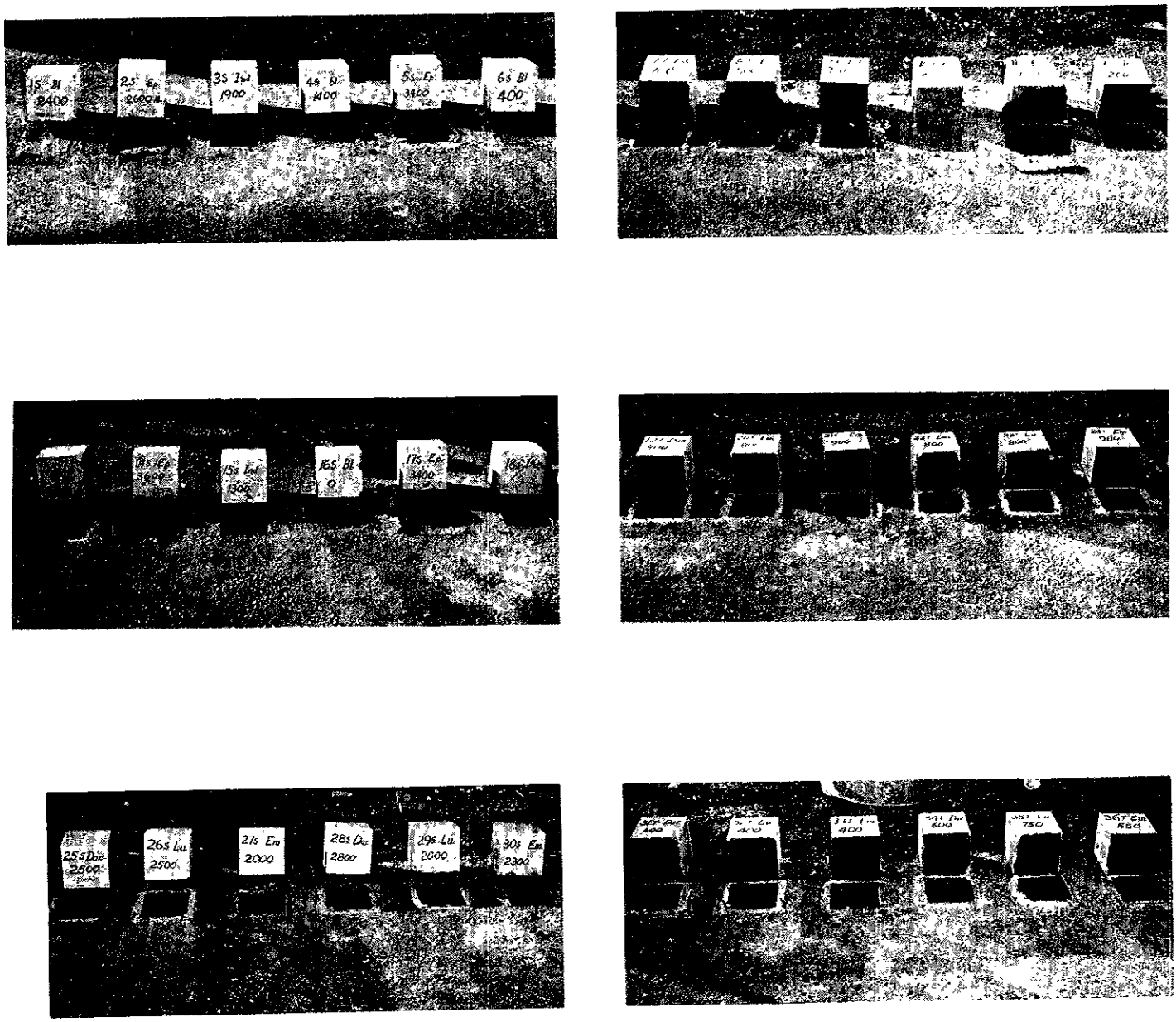


The "Cantilever" Test



The "Shear" Test

Figure 2



BLOCKS AND PAVEMENT AFTER TEST
Shear tests, left column
Cantilever tests, right column

LEGEND FOR FIGURE 2

(Reading from left to right)

LEFT COLUMN, SHEAR TESTS

Top Row

Blank, Epon 820, Indaco, Blank, Epon 820, Blank

Second Row

Blank, Epon 820, Indaco, Blank, Epon 820, Indaco

Bottom Row

Daraweld, Neoprene, Asphalt Emulsion, Daraweld, Neoprene, Asphalt Emulsion

RIGHT COLUMN, CANTILEVER TESTS

Top Row

Indaco, Epon 820, Indaco, Blank, Epon 820, Indaco

Second Row

Daraweld, Neoprene, Asphalt Emulsion, Daraweld, Neoprene, Asphalt Emulsion

Bottom Row

Daraweld, Neoprene, Asphalt Emulsion, Daraweld, Neoprene, Asphalt Emulsion